

WHAT IS CLAIMED IS:

1. An actuator comprising:

a substrate extended in a predetermined direction;

a vibrating member supported on the substrate

5 vibratably in the predetermined direction;

a vibration generating portion configured to  
vibrate the vibrating member in the predetermined  
direction;

a movable member having a first facing surface  
10 confronting the substrate and a second facing surface  
confronting the vibrating member;

a movable electrode disposed at any one of the  
first facing surface and second facing surface of the  
movable member; and

15 a counter electrode disposed on any one of the  
substrate and the vibrating member so as to confront  
the movable electrode, wherein

a potential difference is applied between the  
movable electrode and the counter electrode to cause  
20 an electrostatic force to act such that an apparent  
friction between the vibrating member and the movable  
member is greater than an apparent friction between  
the substrate and the movable member when displacing  
the vibrating member in a desired direction relatively  
25 on the substrate by vibrating in the predetermined  
direction, and thereby the movable member is relatively  
moved in the desired direction on the substrate.

2. The actuator according to claim 1, wherein  
a potential difference is applied between the movable  
electrode and the counter electrode to cause an  
electrostatic force to act such that an apparent  
5 friction between the substrate and the movable member  
is greater than an apparent friction between the  
vibrating member and the movable member, and thereby  
the movable member is stopped on the substrate.

3. The actuator according to claim 1, wherein the  
10 potential difference between the counter electrode and  
the movable electrode varies in synchronism with the  
vibration of the vibrating member.

4. The actuator according to claim 3, wherein  
a potential varying in synchronism with the vibration  
15 of the vibrating member is applied to any one electrode  
of the counter electrode and the movable electrode, and  
a fixed potential is applied to the other electrode.

5. The actuator according to claim 3, wherein  
there is a moment at which the potential difference  
20 between the counter electrode and the movable electrode  
becomes 0 in synchronism with the vibration.

6. The actuator according to claim 1, wherein  
a plurality of movable members each having the movable  
electrode disposed therein are provided, and the  
25 plurality of movable members move independently from  
each other.

7. The actuator according to claim 6, wherein

independent potentials are applied to the movable electrodes disposed in the plurality of movable members, whereby the plurality of movable members move independently from each other.

5           8. The actuator according to claim 6, wherein the movable members include optical elements.

9. The actuator according to claim 8, further comprising an optical element fixed to any one of the substrate and the vibrating member.

10           10. The actuator according to claim 1, wherein the counter electrode is an electrode configured so that the area thereof facing the movable electrode varies depending on the position in the moving direction of the movable member, and

15           the position of the movable member is detected by making use of variation of the facing area.

11. The actuator according to claim 10, wherein the variation of the facing area is detected by measuring the electrostatic capacity between the counter electrode and the movable electrode.

20           12. The actuator according to claim 1, wherein the counter electrode is an electrode divided into plural portions including a first region,

25           the first region has a shape such that the area facing the movable electrode changes depending on the position in the moving direction of the movable member, and

the position of the movable member is detected on the basis of the change in electrostatic capacity between the first region and the movable electrode.

13. The actuator according to claim 1, wherein

5       the counter electrode is an electrode divided into plural portions including a first region and a second region,

10       the first region and second region each have a shape such that the area facing the movable electrode changes depending on the position in the moving direction of the movable member, and

15       the position of the movable member is detected on the basis of the change in ratio of electrostatic capacity between the first region and the movable electrode with respect to the electrostatic capacity between the second region and the movable electrode.

14. The actuator according to claim 1, wherein the vibration generating portion is configured of a piezoelectric vibrator which couples the substrate and the vibrating member.

15. The actuator according to claim 1, wherein the vibration generating portion includes:

an elastic member which couples the substrate and the vibrating member;

25       a first driving electrode disposed on the vibrating member; and

a second driving electrode which faces the first

driving electrode and disposed on the substrate so as to generate an electrostatic force in a desired direction, wherein

5 a potential difference is applied between the first driving electrode and the second driving electrode to cause an electrostatic force to act, thereby generating vibrations.

16. The actuator according to claim 1, wherein at least one surface of the counter electrode and the movable electrode is covered with an insulator.

17. An actuator comprising:

a substrate extended in a predetermined direction;

a vibrating member supported on the substrate vibratably in the predetermined direction;

15 a vibration generating portion configured to vibrate the vibrating member in the predetermined direction;

20 a movable member having a first facing surface confronting the substrate and a second facing surface confronting the vibrating member;

a movable electrode disposed at any one of the first facing surface and second facing surface of the movable member; and

25 a counter electrode disposed on any one of the substrate and the vibrating member so as to confront the movable electrode, wherein

a potential difference is applied between the

movable electrode and the counter electrode in  
synchronism with the vibration of the vibrating member,  
and by using the generated electrostatic force, the  
movable member is moved relatively on the substrate in  
a desired direction.

18. An actuator comprising:

a substrate extended in a predetermined direction;

a vibrating member supported on the substrate  
vibratably in the predetermined direction;

a vibration generating portion configured to  
vibrate the vibrating member in the predetermined  
direction;

a movable member having a first facing surface  
confronting the substrate and a second facing surface  
confronting the vibrating member;

movable electrodes disposed at the first and  
second facing surfaces of the movable member;

a first counter electrode disposed on the  
substrate so as to confront the movable electrode; and

a second counter electrode disposed on the  
vibrating member so as to confront the movable  
electrode, wherein

a potential difference is applied between the  
movable electrode and the first and second counter  
electrodes to cause an electrostatic force to act such  
that an apparent friction between the vibrating member  
and the movable member is greater than an apparent

friction between the substrate and the movable member when displacing the vibrating member in a desired direction relatively on the substrate by vibrating in the predetermined direction, and thereby the movable member is relatively moved in the desired direction on the substrate.

19. The actuator according to claim 18, wherein voltages mutually different in phase are applied to the first counter electrode and second counter electrode.

10        20. The actuator according to claim 19, wherein voltages mutually reverse in phase are applied to the first counter electrode and second counter electrode.

21. The actuator according to claim 18, wherein  
15        the substrate is disposed at both sides of the vibrating member so as to enclose the vibrating member in a direction orthogonal to the vibrating direction of the vibrating member on the substrate surface, and

20        the first counter electrode confronting the movable electrode is disposed at both sides of the vibrating member.

22. A driving method of an actuator, the actuator including a movable electrode disposed on a movable member, and a counter electrode disposed at any one of  
25        a facing surface of a substrate having the facing surface confronting the movable member and a facing

surface of a vibrating member having the facing surface  
confronting the movable electrode and vibrating in  
a predetermined direction, applying a voltage to the  
movable electrode and the counter electrode, thereby  
5 causing the movable member to move relatively on the  
substrate, the driving method comprising:

displacing the vibrating member in a desired  
direction relatively on the substrate; and

10 applying a potential difference between the  
movable electrode and the counter electrode such that  
an apparent friction between the vibrating member and  
the movable member is greater than an apparent friction  
between the substrate and the movable member when  
displacing the vibrating member relatively.

15 23. A driving method of an actuator, the actuator  
applying a controlled voltage to a movable electrode  
disposed on a movable member, a first counter electrode  
disposed at a facing surface of the substrate having  
the facing surface confronting the movable electrode,  
20 and a second counter electrode disposed at a facing  
surface of the vibrating member having the facing  
surface confronting the movable electrode and vibrating  
in a predetermined direction, thereby causing the  
movable member to move relatively on the substrate, the  
25 driving method comprising:

displacing the vibrating member in a desired  
direction relatively on the substrate; and



applying a potential difference between at least the second counter electrode and the movable electrode when displacing the vibrating member relatively.